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Ultrafast All-Optical Switching in TiO_2

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Abstract Titanium dioxide (TiO_2) is a promising yet unexplored material for ultrafast, on-chip nonlinear optical devices. Here, we explore TiO_2′s capacity for nonlinear applications and then fabricate linear on-chip devices using this material. We measure TiO_2′s Kerr nonlinearity to be 30 times that found in silica glass by using the *Z*-scan technique with a bulk sample. During the same experiment, the low two-photon absorption observed can enable all-optical applications around 800 nm. To realize devices, we require waveguides made from thin films of TiO_2. We deposit our thin films on oxidized silicon wafers using reactive sputtering of titanium metal in an oxygen environment. This method produces thin films with a high refractive index (2.4) and low planar waveguiding losses (<0.4 dB/cm). Using these films, we define structures with electron-beam lithography. Next, we form waveguides using reactive-ion etching to achieve feature sizes in TiO_2 down to 100 nm. We show both visible and 780-nm light propagation in 300-nm wide waveguides. Lastly, we test simple linear devices such as bends, directional couplers, and Sagnac interferometers. From our observations of the nonlinear optical properties in bulk samples and our demonstration of basic on-chip devices, we conclude that TiO_2 is a viable material for all-optical applications.

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